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Long-Term Dynamics of Viticultural Landscape in Cyprus—Four Centuries of Expansion, Contraction and Spatial Displacement

Evangelos Papadias [1], Vassilis Detsis [2], Antonis Hadjikyriacou [3], Apostolos G. Papadopoulos [1], Christoforos Vradis [1] and Christos Chalkias [1,*]

[1] Department of Geography, Harokopio University, 17676 Kallithea, Greece; papadias@hua.gr (E.P.); apospapa@hua.gr (A.G.P.); cvradis@hua.gr (C.V.)
[2] Department of Economics and Sustainable Development, Harokopio University, 17676 Kallithea, Greece; detsis@hua.gr
[3] Department of Political Science and History, Panteion University, 17671 Athens, Greece; ant.hadjikyriacou@panteion.gr
* Correspondence: chalkias@hua.gr

Abstract: Viticulture has historically been an important part of the social and economic life in the Mediterranean, while wine is reckoned among the oldest documented trades. The aim of the study is to record, evaluate and analyze spatial data from historical sources in order to gain insights into the dynamics of the viticultural landscape from the beginning of the Ottoman period to the present day. The study was based on (a) three historical maps published in 1885, 1942 and 1969, (b) records from historical surveys—two from the Ottoman period (1572 fiscal survey, 1832/33 property survey) and the British agricultural census of 1931, (c) present-day records from the vineyard survey of 2009 carried out by the Republic of Cyprus. In the beginning of the study period the center of viticulture was well established within the area of the southern and eastern slopes of Troodos massif. The vineyards expanded mainly around the same growing area until WW2 when they gradually began to be relocated in southwest direction to lower altitudes. This long-term trajectory of spatial patterns was driven by external demand for the product but also by the interplay of environmental, topographic and cultural factors, as well as by the state's policy framework which largely reflected long-term Mediterranean-wide patterns.

Keywords: viticulture; historical GIS; Cyprus; eastern Mediterranean; historical change; landscape dynamics

Citation: Papadias, E.; Detsis, V.; Hadjikyriacou, A.; Papadopoulos, A.G.; Vradis, C.; Chalkias, C. Long-Term Dynamics of Viticultural Landscape in Cyprus—Four Centuries of Expansion, Contraction and Spatial Displacement. *Land* **2023**, *12*, 1143. https://doi.org/10.3390/land12061143

Academic Editor: Jiquan Chen

Received: 28 April 2023
Revised: 19 May 2023
Accepted: 27 May 2023
Published: 29 May 2023

1. Introduction

The identities of land systems are shaped through long-term trajectories, the origins of which have to be traced in the distant past. Understandings of these dynamics derived from empirical studies that span a few decades have a limited ability to shed light on the formation of current patterns. Extending the study of land use and land cover change to the more distant past has been pointed out as a gap that needs to be filled to enable a better comprehension of the involved processes [1]. These kinds of studies present significant methodological challenges due to large time gaps in the availability of information and the need to combine sources of different nature and origin not strictly comparable among them and with current sources [2]. Furthermore, the accuracy of the available historical sources usually cannot be estimated beyond any doubt. Processing data from historical sources, such as maps and censuses using GIS, can provide spatial insights into the multi-temporal analysis of past landscape/land cover changes (among others [3–7]).

Cyprus passed under Ottoman control in 1571 and remained under that status until 1878, with the inauguration of British rule. The British era lasted until the Declaration of Independence of the Republic of Cyprus in 1960. The present-day de facto partition was

the result of political and military actions in 1974. Archaeological evidence suggests that wine production has been practiced in Cyprus for 4 millennia. Written sources point to external trade of Cypriot wine since, at least, the Roman times. It is well-documented as an important trade commodity at least since the Second Crusade in the mid-12th century and it has retained its importance ever after under widely different regimes [8–10]. The importance of wine as an external trade commodity led to the availability of a larger amount of information about viticulture in historical times compared to other land uses, spanning a period of about 440 years. Therefore, Cypriot viticulture provides the opportunity to trace the century-scale evolution of the associated land system.

Historical vineyard landscapes have been studied worldwide as viticulture has a long and rich history dating back thousands of years. Under many different approaches including economics, history, archaeology and geography and using a range of methods, various relationships between viticulture and landscape have been explored [4,11–22]. Several studies have used GIS in studying the historical dynamics of viticulture offering more spatially explicit insights. Results have revealed complex and divergent historical trends that lie beneath the viticultural activity and different drivers of change in the long term across landscapes worldwide [23–26], to which this work aims to contribute.

The objective of the present study is to trace the dynamics of the spatial distribution of viticulture in Cyprus, since the late 16th century and determine the degree to which it reflects the bigger, Mediterranean-wide picture. Wine has been a commodity intended for external trade since pre-modern times until the current phase of globalization; therefore, unlike subsistence farming, viticulture has always been affected by distant drivers [27]. The working hypothesis of this study is that external demand for wine can be assumed to be the principal driver for the coarse patterns observed regarding overall production and the area devoted to viticulture. On the other hand, finer-scale patterns for the exact locations of production and internal shifts are driven by a more complicated interplay among distant and localized drivers. These include the available technology and means of production, the profitability of viticulture versus alternative crops and the availability of alternative livelihoods unrelated to agriculture as well as suitability of the environment, agricultural policies, culture and population movements, which unfold involving a large number of processes and actors operating at different scales [28]. Local-level land cover reconstructions provide the opportunity to make use of a wide range of historical sources that can provide insights in this interplay and take into account in a comprehensive way historical events affecting the place in question [1,29,30]. Such an approach allows for the identification of processes leading to either persistence or change in land systems, by treating the effects of drivers in the context of the specific places [31].

Methodologically, the present study deviates from similar studies in trying to establish a timeline based on different kinds of sources for each time period. Long-term studies usually build on a long series of comparable sources, such as historical maps [2,32] or archival documentation [33,34]. In the case of Cypriot viticulture, a range of different documentation—such as historical maps of the 19th and 20th centuries, the 1572 Ottoman fiscal survey and the 1832/33 property survey, the British Agricultural survey of 1931 as well as modern data sources—has been combined to establish the long-term spatial arrangement of this land system. Following the evaluation of the reliability of these sources, and the compatibility among them, the study proceeds with detecting the area of viticulture as well as horizontal and vertical displacements of vineyards to (a) quantify in a spatially explicit way patterns of persistence and change and (b) relate the observed spatial processes to the wider context (social, economic, political and historical dimensions), in order to decipher the interplay of the drivers that shaped the distribution of the involved land systems.

This particular case study constitutes a lens through which the socio-economic, political and spatial changes that have affected the island of Cyprus in the long term, can be observed.

2. Materials

2.1. Study Area

Cyprus lies in the eastern end of the Mediterranean Sea, and it is its third largest island after Sicily and Sardinia. Complex tectonic movements that started 90 million years ago raised from the bottom of the ancient ocean Tethys the Troodos massif to the south followed by the Keryneia or Pentadaktylos range to the north and eventually the central plain of Mesaoria. Clastic sediments from the extensive bedrock erosion of these imposing mountain ranges were deposited between them at Mesaoria and formed large valleys around them. As geomorphology is still correlated with geology, the detailed study on behalf of the Geological Survey Department of Cyprus [35], defined eight major physiographic regions sharing common morphological attributes (Figure 1) by considering four environmental factors: landforms, geology, vegetation and soil.

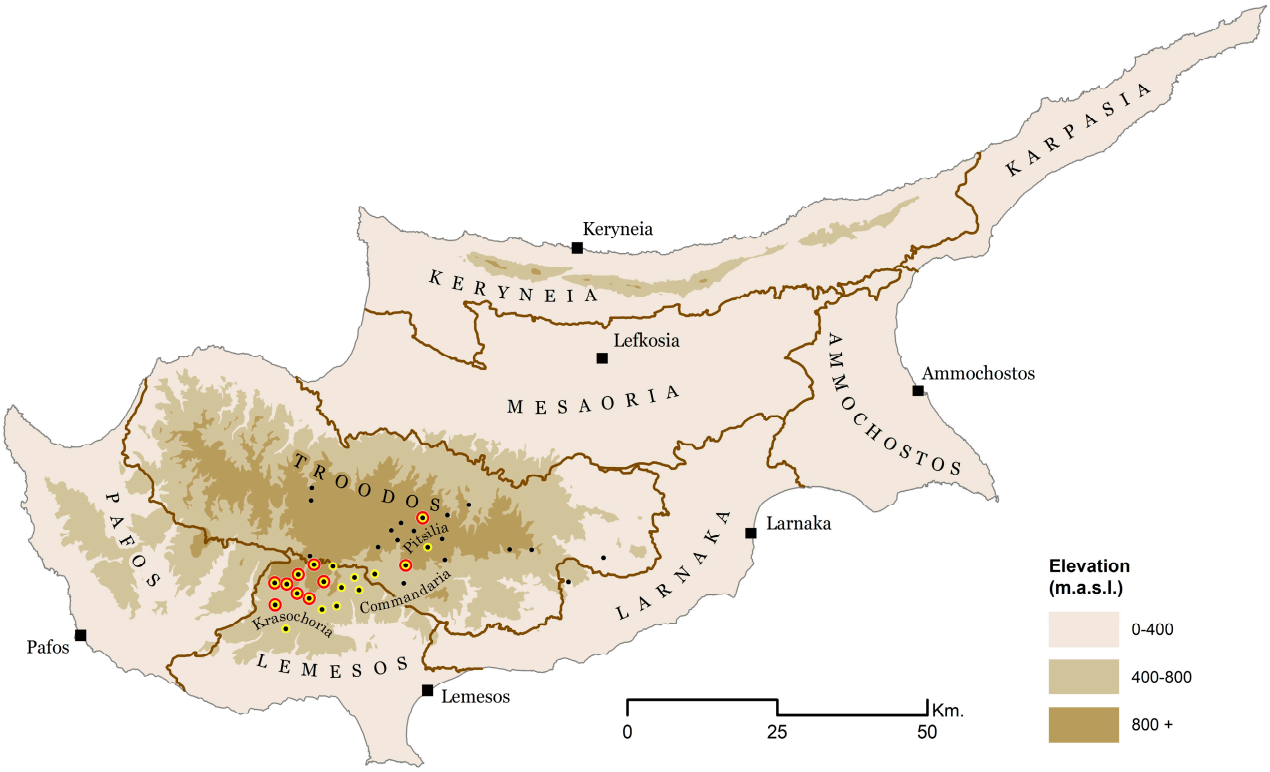

Figure 1. The eight major physiographic regions of Cyprus [35]. Black circles represent settlements with significant viticulture activity throughout the Ottoman period (1572–1878). Yellow circles represent settlements with significant viticulture activity throughout both the Ottoman and British period (1572–1960). Red circles represent settlements where viticulture activity continued to be significant until the modern era.

2.2. Sources

2.2.1. Map Data

The AMS K715 map series (2nd edition) [36] (hereinafter "K715") published in 1969 by the Corps of Engineers of the U.S. Army Map Service was retrieved from the Library of Congress. It was prepared in 25 sheets at a scale of 1:50,000 and compiled from previous printed material of 1964 having details revised by photo-planimetric methods and field checks in 1967. The reference system of this map is the ED50/UTM zone 36N (EPSG: 23036). The map is rich in landscape features and vineyards are clearly depicted.

The GSGS 4242 map series (2nd edition) [37] was published in 1942 by the General Staff of the Geographical Section of the British War Office. It was prepared in 16 sheets at a scale of 1:50,000 compiled from cartographic material at a scale of 0.5 miles to 1 inch (1:31,680) supplied by the Cyprus Department of Lands and Surveys. Details were revised

in 1941–1942 using aerial photos, while the reference system of the map is based on Cassini-Soldner projection and Clarke 1880 spheroid.

Kitchener's map (hereinafter "K-map"), published by Edward Stanford in 1885, is considered a milestone in the cartography of Cyprus. It is the first trigonometrical survey of the island and was printed in 16 sheets at a scale of one mile to one inch (1:63,360). Responsible for the survey was Horatio Herbert Kitchener after having his first surveying experience in the British expedition in Palestine. The map offers a unique window to study the geography, history and culture of the island as it is a rich and invaluable source of a multitude of detailed information. However, land cover information is very poor and absolutely no information is provided for about 54% of the island which was categorized as "Unclassified" type of land cover [38]. Kitchener's historical map is the only source that provides professionally surveyed geographic data for Cyprus in the 19th century.

Vineyards are the only crop clearly depicted on all the above-mentioned maps as a separate category, probably due to their economic importance. All other crops were included in more general groups such as orchards, cereals, gardens, or unclassified parts of the maps.

Soil data were extracted from the 1999 soil map of Cyprus found in the detailed study on behalf of the Geological Survey Department of Cyprus [35]. Bioclimatic regions were available by the Department of Environment of Cyprus [39].

2.2.2. Censuses/Surveys

Right after the conquest and settling of the army, Ottomans carried out a detailed fiscal survey aiming to record any taxable wealth resource for their new province [40,41]. The survey of 1572 provides valuable information about the economy, production, placenames, settlements and much more and, unsurprisingly, data about wine are present. Wine is enlisted as "grape juice" (*Sira*) and measured in loads (*himl*) (Table 1). Detailed data for every settlement of the island were made available by the research project "Mediterranean Insularities" hosted at the Institute for Mediterranean Studies, Foundation for Research and Technology-Hellas and were georeferenced by the Department of Geography of Harokopio University, Athens as part of the project "Economy, environment, and landscape in the Cypriot *longue durée*" funded by the Sylvia Ioannou Foundation [42]. Considering that the rate for the *tithe* was set at 20% by sultan Selim II [41], the 17.087 loads recorded in the register amount to a total wine quantity of 85.435 units.

Table 1. Available datasets of viticulture extent in Cyprus. Ranges of possible values are not given in the earliest surveys, due to uncertainties of the area measurement unit used as well as viticulture productivity unit in 1572. For the year 2009 the values refer to the southern part of Cyprus.

Type	Year	Reference Unit	Quantity	Units	Area Estimation (km^2)
survey	1572	settlement	85,435	load	-
survey	1833	settlement	39,976	*dönüm*	-
map	1885	area	238.3	km^2	238.3
survey	1931	settlement	162,101	*dönüm*	216.9
map	1942	area	510.8	km^2	510.8
map	1969	area	459.4	km^2	459.4
survey	2009	municipality	88.29	km^2	88.29

The Ottoman property survey of 1832/33 is of similar depth recording taxable quantities and values for every product and property in every settlement on the island. Detailed data for every settlement of the island were made available as an outcome of the research project "Economy, environment, and landscape in the Cypriot *longue durée*", funded by the Sylvia Ioannou Foundation. This source contains data for 6.433 vineyard records, for which both their area and their value are recorded in *dönüm* and *kuruş*, respectively. The total area of vineyards amounts to 39.976 Ottoman *dönüm*.

The British Agricultural Census of 1931 [43] is the first of a series of decennial censuses, disrupted by WW2, to record agricultural data for each settlement by means of a census using questionnaires. Categories of land uses are enlisted only for arable land, gardens and vineyards for which total area amounts to 162.101 *dönüm* (Table 1). Although grape production as well as exported viticultural products such as vinegar, wine and raisins are registered in the yearly British Colonial statistical reports from 1887 onwards [44], areas under vines appear in these reports only since 1931. The British Agricultural Censuses of 1946 [45] and 1960 [46] were not of the same depth as the one of 1931. Detailed records have not been published separately for every settlement but have been aggregated in the six main districts and broad geographical areas, therefore they were not taken into account.

The Statistical Service of Cyprus published in 2011 the results of the "Census of Vines 2009" [47]. The survey records the area under vines for each municipality for the Government controlled area excluding the northern part of the island occupied by Turkish military forces since 1974. The total area of holdings with grape plantations in 2009 amounted to 88.920 decares, which translates to 88.29 km^2. Considering that more than 90% of the viticultural activity between 1572 and 1969 took place in the southern part of the island, the report of 2009 can be considered to reflect the modern era transformation of past viticulture. The attributes of each municipality were assigned to the main settlement of each administrative area. However, data from this report are organized by the property holder's place of residence—not the actual site of the property holding.

Population data for each settlement were drawn from the nearest census in time to our geographic data source and more specifically, the censuses of 1572, 1831, 1891, 1931, 1946, 1960 and 2011. All censuses record persons except the census of 1572, in which the number and details about the households are given instead. The census of 1572 records very few Muslims on account of the recent arrival of the Ottomans (23 persons), as does the census of 2011, since the number of Muslims living in the areas under the control of the Republic of Cyprus is very small. The Census of 1831 included only the male population, both Muslim and non-Muslim [48].

2.2.3. Reliability of, and Compatibility, among Sources

The above-described primary sources display major differences between them in terms of the quality and reliability of data. This does not exclude the possibility of a transtemporal analysis. Yet, such an exercise requires a thorough and careful examination of the limitations and a consideration of different ways in which these snapshots can provide insights for the long-term evolution of viticulture in Cyprus.

First of all, there is a serious discrepancy in the kind of available data. Cartographic sources record vineyards as land use; censuses record either the estimated production of grape juice (1572), or the size and monetary value of vineyards (1832/33, 1931). More serious is the challenge of converting measures and units. The problem of metrology is quite serious in Ottoman studies, with significant divergences in standardization across time and space not only throughout the empire, but even within provinces. Halil Inalcik has contributed greatly towards a better understanding of Ottoman metrology [49,50], but his diligent attempt to establish metric conversion units for Ottoman measures across time and space gives a false impression of standardization, leading historians to unscrupulously use his tables. A case in point is the *dönüm*. As late as 1931, and after half a century of colonial rule and several attempts of standardization, the British have explicitly admitted the unreliability of data for land size based on the *dönüm*, given that the measure is measured in different sizes across the island [43].

Secondly, the fact that different surveys record incompatible data constitutes a major challenge. For example, the 1572 survey records production, while the 1832/33 or subsequent British and post-independence surveys record land size. We have mitigated this problem by cartographically representing the spatial distribution of viticulture-related data without necessarily comparing absolute figures, which allows us to establish the expansion, contraction, or condensation of viticulture. We use the resulting maps as analytical and

heuristic tools with reference to our research questions. The integration of data from different sources is one of the main methodological strategies of this paper, although it presents some challenges that have been adequately addressed. The most important pathway to ensure data integration is through clear rationale and differentiated research design. Thus, the key to convergent validation (triangulation) is to maintain "quality of design" and "interpretive vigour" while the mixture of data is also a feature of our analysis [51]. More specifically, data integration in this case, as in many others, is a matter of innovation. with data integration, we do not seek to obscure the complexity of socioeconomic and spatial processes, but rather to reveal them [52].

3. Methods

3.1. Geodatabase Creation

3.1.1. Map Georeferencing

Georeferencing maps produced in the second half of the 20th century is a straightforward process. Most of them have been drawn using a well-documented coordinate system, for which the essential transformation parameters in order to match modern geographic grids are well known and integrated in modern GIS software packages and their libraries. On the other hand, historical maps of the 19th century, in most cases, lack essential coordinate system information and in order to transfer features from the map to the GIS environment, quite a large set of control points must be identified.

Regarding the allocation of control points, for the GSGS 4242 and K715 maps, we focused on the coordinate system, while for K-map we focused on landmarks and especially on churches and monasteries as previously described [38]. The K715 map was georeferenced according to its reference grid and the mean rectification accuracy of this basemap, applying a first order affine transformation, was 5.5 m. The GSGS 4242 map sheet distribution corresponds to the 1:5000 Cassini cadastral plan sheet distribution, available by the Department of Lands and Surveys of the Republic of Cyprus [53], transformed to the modern and official Cyprus Local Transverse Mercator system (EPSG:6312). Then, the GSGS 4242 map sheets were rubber-sheeted using a spline transformation to fit the sheet borders to the distribution quadrangles.

In order to assess the comparability and accuracy of the three topographic maps, we collected 354 trigonometric stations from the GSGS 4242 map, which were compared with the corresponding locations on the K715 map, yielding a Root Mean Square Error (RMSE) of 41.52 m. Following our previous work [38], a set of 340 validation Control Points (CP), churches and monasteries, selected from the CPs dataset used to georeference the K-map, was identified in both the K-map the and GSGS 4242, yielding a total RMSE of 71.32 m. Taking into account that the total RMSE between K-map and K715, using also a subset of the CPs used to georeference the K-map, was calculated previously at 68.76 m [38], the convergence between the three maps, about one millimeter of map's scale, was considered satisfactory for the scale of the study. After the georeferencing process, features from each map were digitized and organized in an appropriate spatial form (polygon layers) within the GIS environment of ArcGIS 10.8.1.

3.1.2. Censuses Geolocation

The data from the three historical surveys of 1572, 1832/33 and 1931 were made available as an outcome of two research projects as described in Section 2.2.2. Attributes of viticulture had been organized for every recorded settlement in the form of tabular data. Modern survey data were manually digitized from the published tables and were matched to their corresponding municipality spatial polygons. Additional information about the historical surveys can be found in (https://ecoland.hua.gr/en/ accessed on 15 May 2023).

Records from the three historical surveys were geolocated as described in previous work [42], using K-map as the main source of locations. From the census of 1572, 95.38% out of the total quantity of the wine in 246 settlements was geolocated successfully and the remainder 4.62% is related to 31 abandoned settlements, most of which (17) were in

the Nicosia district. From the census of 1832/33, 98.58% of the vineyard area found in 332 settlements, was geolocated successfully. In the census of 1931, vines were found present in 673 settlements and were geolocated in 100%. The survey of 2009 recorded vineyard areas for 310 municipalities and every record was assigned successfully to its corresponding spatial unit.

3.1.3. Topographic Position Index

Topographic Position Index (TPI) was developed in detail by Weiss [54] and is calculated, using a moving window, as the difference between the value of a cell and the mean value of a specified neighborhood around that cell. Neighboring cells are defined using an annulus with inner and outer cell radius in this case, but other shapes could also be used as well. Positive values of TPI represent ridges, negative values represent valleys while values near zero represent gentle slopes which are either flat areas or areas of constant slope. This basic algorithm coupled with a slope analysis yields six slope position classes and implemented in different scales results in a ten landforms classification scheme. It is used in a wide range of applications for which the morphology of the relief is a determining factor [55,56]. In this study we used the slope position classification scheme calculating TPI from a medium resolution (30 m cell size) DEM [57], using an annulus neighborhood of 30 m inner radius and 510 m outer radius. After the classification process, the total area of each category (Gentle slopes, Steep slopes, Upper slopes, Ridges, Lower slopes and Valleys) within each municipality was assigned as attribute to every feature.

3.1.4. Data Integration

In order to establish comparability between these heterogeneous datasets, the detailed spatial data (points and polygons) were aggregated using the borders of the municipalities of the Republic of Cyprus. In many cases we found that geographical features such as ridges and hydrographic network branches are being reflected on them. Furthermore, a sample check revealed that the borders described in the first detailed cadastral plans (1:5000) of the period 1920–1930 in most cases were preserved. Thus, municipality borders were considered to be representative of the cultivated vicinity of each settlement. The sum of the values of each dataset was then assigned to the main settlement of each municipality (Figure 2). Following the same procedure, we computed the spatial intersection between the layer of the municipalities and the layers of bioclimatic regions, soil types and landforms defined by TPI calculations in order to cross-tabulate the area of each layer's subtypes within each municipality. The values were then assigned to the main settlement along with the median value of the elevation of every municipality and the corresponding population attributes (Total, Muslim, non-Muslim) of the closest listing in time. All attributes were combined in a single table as described in Table 2.

Table 2. Summary of the attributes used in regression analysis and their corresponding units.

Variable	Sub-Categories (Columns)	Units
Total area of each municipality	1	ha
Viticulture	7	ha, except 1572
Population	17	Number of persons
Elevation	1	m.a.s.l.
T.P.I.	6	ha
Bioclimatic regions	8	ha
Soil types	4	ha

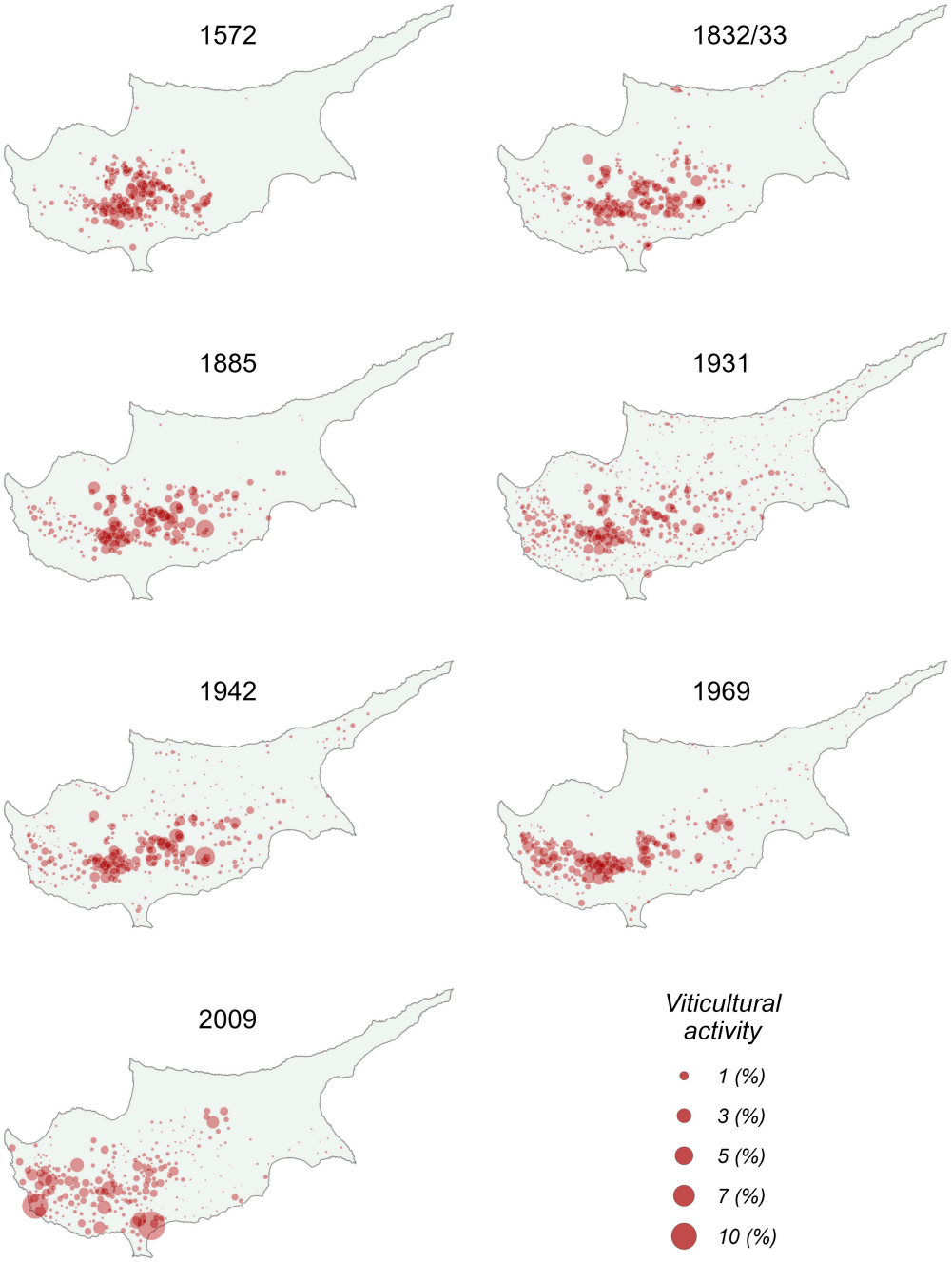

Figure 2. The detailed spatial distribution of viticulture activity from all available sources. Original values have been aggregated within the boundaries of the municipalities of the Republic of Cyprus and the attributes have been assigned to its main settlements. Symbol size is relative to the magnitude of each feature's attribute and represents the percentage of the activity in the respective date. Settlements with recorded areas less than five *dönüm* have been omitted from the graphics of the censuses of 1832/33 and 1931.

3.2. Statistical Analysis

3.2.1. Regression

A zero-inflated negative binomial model [58] was fitted to the data of the three physiographic regions (Lemesos, Pafos, Troodos) that account for over 90% of the Cypriot viticultural activity throughout the examined period, in order to describe the effects of various environmental and social variables on the extend of viticulture per settlement, which was used as the response variable. The choice of the model was dictated by the features

of the response variable distribution; the variance was different from the mean with an excessive number of zeroes and it cannot take negative values. This type of model consists of two parts, a logistic model accounting for the excess zeros and a negative binomial model dealing with the rest of variability. Estimated area of viticulture in hectares per settlement was used as the dependent variable, except for 1572, for which production in loads was used. Settlement area was used as an offset variable. Several different models including various explanatory variables were tested and compared in terms of AIC minimization and residual testing by means of qq-plots and plots of residuals against predicted values along with quantile regression curves compared with the theoretically expected ones. Christian population, elevation, soil types and TPI categories were used as explanatory variables, while bioclimatic types and long term mean values of climatic indices as well as inclination were also tested and dropped since they lead to inferior fit. Christian population equaled the total population in 1572 and 2009, but not in the other cases. Including the Muslim segment of the population in the model also led to insufficient fit. Soil types and TPI categories were quantified by summarizing the area of each settlement that falls within each category. After finalizing the model, an additional check was carried out by plotting Tukey's Rootograms.

The explanatory variables were scaled so as to make the estimated coefficients comparable within and between dates, except for 1572 in which the dependent variable is expressed in different units. In this case the coefficient values are comparable only within the model for year 1572.

The analysis was conducted in R [59] with glmmTMB [60] and residual testing with package DHARMa [61]. Rootograms were plotted by rerunning the analysis with package countreg [62,63]. Figures were produced using the package ggplot2 [64].

3.2.2. Spatial Autocorrelation

Spatial autocorrelation statistic, local Morans' *I*, was calculated using R [59] with spdep package [65] using as variable the viticulture attribute of each dataset. We used as input spatial dataset the municipalities' polygons considering regions with contiguous boundaries as neighbors following the contiguity criterion. Local Indicators of Spatial Association, LISA clusters figures, were produced using the package ggplot2 [64].

3.2.3. Weighted Mean Center

The weighted mean center represents the geographic center of a set of locations, considering the relative importance of each location as determined by its weight. The calculation was performed using the coordinates (Xi, Yi) of the central settlement of each municipality using as weight (wi) the values of the aggregated viticultural data from each dataset within the limits of each municipality polygon. The coordinates of the weighted mean center for each dataset were calculated using the formula:

$$Xmean = (\Sigma(wi \times Xi)) / \Sigma wi$$

$$Ymean = (\Sigma(wi \times Yi)) / \Sigma wi$$

Calculations were carried out was using R [59].

4. Results

Vineyards upon the Ottoman conquest were found to be concentrated in the southern part of the island and specially in the Troodos massif and the hilly and semi-hilly areas located at its southern slopes. Wine production was nearly absent in the Central plain and the rest of the northern part. Just one small settlement (9 households—15 loads) is recorded in 1572 register for Keryneia region and nothing at all for Ammochostos. Clearly the higher altitudes of Troodos and the surrounding hills was the main viticultural landscape of the late Venetian period encapsulated in the survey of 1572. After 260 years under Ottoman rule and having no other formal source of agricultural records, vines in 1833 are found

more scattered and slightly moved to the eastern and western hills of Troodos but still unequally distributed in the north-south direction. The vast majority, over 80% out of the total recorded area, lies above 400 m in the Troodos massif and the hills. Main production seems to have remained around the same locations where the vine was cultivated in 1572 (Figures 2–4), spreading around them and showing clear preference at the height zone of 400–800 m (Table 3). Most of the new locations, compared with 1572, are situated at the southwestern part of Pafos region while Lapithos along with Karavas in Keryneia region were the most contributing villages to the north.

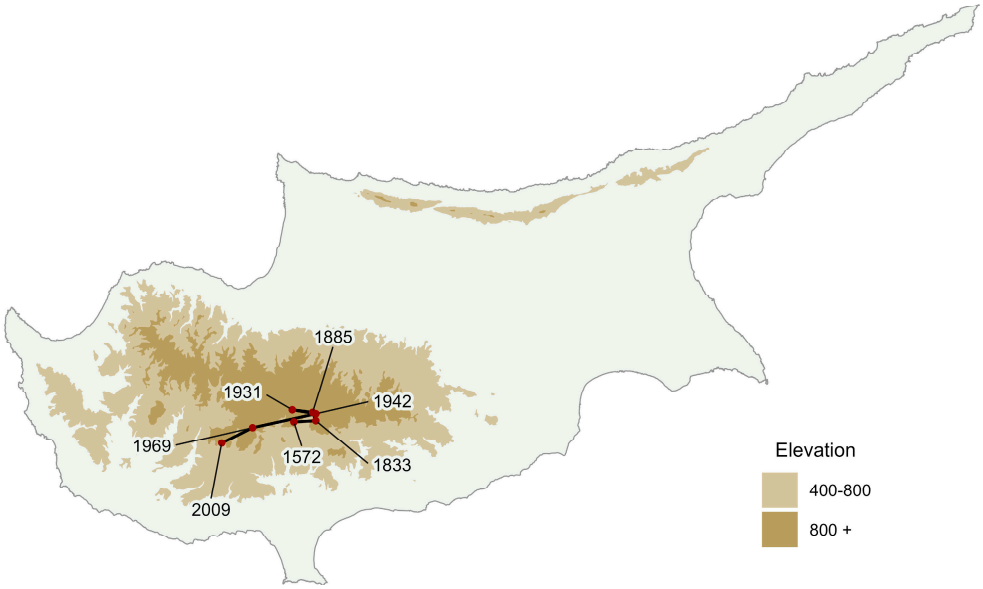

Figure 3. Weighted mean center of viticulture calculated from each year's attributes using the locations of the main settlements of the municipalities of Cyprus.

The early 1860s found France and Europe struggling with phylloxera and Cyprus vine plantations in extension as the demand for wine and alcohol was high. Cyprus enjoys the privilege of not meeting with phylloxera until the present day. The rapid increase in vine cultivation is described by the first Commissioner of Limassol and later Chief secretary to Government, in his annual report after the first year of British administration in July 1879 [66]. However, the recovery of French production, which led to the vine crisis of the 1880s, slowed down the rush for planting in the next decades as wine production suffered depreciation [67] and foreign wine importation was almost prohibited in France in 1891 [68]. Mouillefert, the French professor of viticulture, in his report on the wine industry of the island reports that area under vine cultivation was almost 145.090 *dönüm* (194 km^2) in 1892 [69]. Thus, Kitchener's survey, completed in 1883 and published in 1885, can be assumed to be close to the peak of the spatial expansion of viticulture of the 19th century.

Viticulture at the end of Ottoman era can be considered to be imprinted on Kitchener's map published in 1885. Total viticulture moved slightly to the west but mainly remained at the same communities where it was recorded by the census of 1832/33. Half of the vineyards were found in the height zone 400–800 m and about 86% of the total area is situated above 400 m. TPI analysis reveals that late Ottoman era viticulture was practiced mostly upon inclined broken surfaces as the vast majority was found on slopes and ridges according to the aforementioned map.

Cyprus continued to face vine problems not only at the end of the 19th century but also in the first decades of the 20th and particularly at the end of WW1, during which the global demand was higher and Cyprus's wine exports began to recover due to the engagement of most countries in military operations. Bevan, the director of the Agricultural Department, in 1919 reported a cultivated area of about 140.000 *dönüm* in the hands of some 15.700 vine growers [70]. Compared to Mouillefert's estimations and if they both calculated the *dönüm*

measure the same way, total area covered by vines does not seem to have changed up to the end of the beginning of the 1920s.

Area under cultivation continued to expand over the next decade reaching 162.101 *dönüm* (216.9 km^2) in the Agricultural census of 1931. Nearly half a century after the arrival of the British, vine expanded all over the island. Total viticulture moved slightly to the west with the wider expansion observed to the region of Pafos in lower altitudes. Nearly a quarter of viticulture of this era lies below 400 m.

Viticulture at the beginning of WW2 is being reflected on the British GSGS 4242 map series published in 1942. Vines are concentrated in wider geometries, and a larger area is recorded in total. A movement in Pafos region is also notable (Figures 3 and 4). Also noticeable is the declination of vines in the valleys of Setrachos and Karkotis rivers.

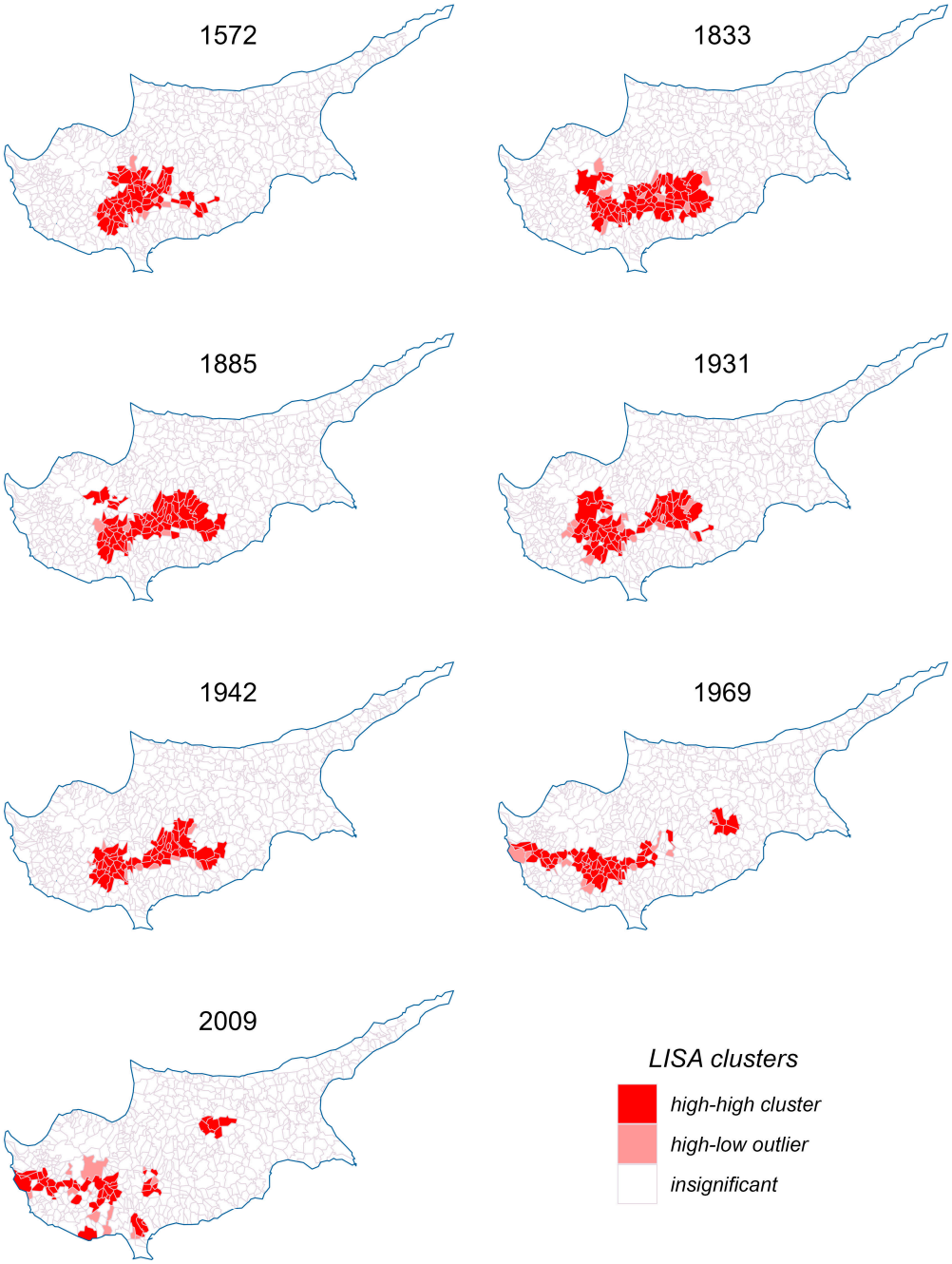

Figure 4. Moran's I Local Indicators of Spatial Autocorrelation (LISA), showing the clustering of viticultural activity.

Table 3. Viticultural activity by physiographic region and elevation zone (m.a.s.l. in brackets). All values represent percentages of each year's unit. 2009 values refer to the southern part of Cyprus.

Region	Elevation	1572	1833	1885	1931	1942	1969	2009
Ammochostos (0–174)	0–200	0	0.11	0.01	0.75	0.25	0.47	0.15
Karpasia (0–383)	0–200	0	0.01	0	0.44	0.34	0.19	-
Keryneia (0–1024)	0–200	0	1.42	0.06	1.24	0.79	0.2	-
	200–400	0.02	0.1	0.01	0.43	0.32	0	-
	400–600	0	0.01	0	0.02	0	0.04	-
	Total	0.02	1.53	0.07	1.69	1.11	0.24	-
Larnaca (0–752)	0–200	0.64	0.55	1.22	2.92	2.13	1.34	2.04
	200–400	3.4	6.1	5.62	2.94	8.24	1.81	0.02
	400–600	0.61	1.92	0.37	0.33	0.89	0.27	0
	Total	4.65	8.57	7.21	6.19	11.26	3.42	2.06
Lemesos (0–1153)	0–200	0.66	2.68	0	2.06	0.52	1.18	19.51
	200–400	1.02	0.74	0.15	0.46	0.04	0.37	1.07
	400–600	12.76	8.57	6.09	7.83	7.68	12.21	5.41
	600–800	11	10.54	11.64	12.03	12.3	15.48	2.95
	800–1000	8.18	6.69	7.74	6.6	7.52	7.8	5.27
	Total	33.62	29.22	25.62	28.98	28.06	37.04	34.21
Mesaoria (0–643)	0–200	0.18	0.27	1.07	3.5	1.01	0.79	4.28
	200–400	0.42	2.15	1.23	2.63	1.82	2.38	1.98
	400–600	1.02	1.4	3.57	2.16	3	0.22	0.22
	Total	1.62	3.82	5.87	8.29	5.83	3.39	6.48
Pafos (0–1145)	0–200	0	0.24	0.08	1.92	0.77	0.92	14.49
	200–400	0.64	0.72	1.44	4.19	1.97	10.22	6.49
	400–600	2.36	2.41	2.62	8.73	4.44	15.49	15.25
	600–800	0.78	2.75	1.06	3.63	2.1	5.2	5.07
	Total	3.78	6.12	5.2	18.47	9.28	31.83	41.3
Troodos (0–1950)	0–200	0	0.02	0.01	0.22	0.11	0.01	0.04
	200–400	0.5	3.33	3.39	3.15	4.62	4.35	0.06
	400–600	7.47	11.73	6.83	3.29	3.21	0.66	0.31
	600–800	9.65	11.55	13.51	8.8	12.28	5.68	4
	800–1000	19.52	13.52	21.41	13.22	17.97	8.3	6.74
	1000–1200	9.88	7.06	6.57	3.77	3.59	3.3	2.16
	1200–1700	9.28	3.43	4.31	2.75	2.09	1.11	2.47
	Total	56.3	50.64	56.03	35.2	43.87	23.41	15.78
Cyprus (0–1950)	0–200	1.49	5.3	2.44	13.04	5.91	5.1	40.52
	200–400	6	13.14	11.84	13.8	17.01	19.14	9.63
	400–600	24.22	26.03	19.48	22.37	19.23	28.89	21.19
	600–800	21.43	24.83	26.21	24.45	26.68	26.36	12.02
	800–1000	27.7	20.21	29.15	19.82	25.49	16.1	12.01
	1000–1200	9.88	7.06	6.57	3.77	3.59	3.3	2.16
	1200–1700	9.28	3.43	4.31	2.75	2.09	1.11	2.47

During WW2, the island never became a battlefield. The global demand for alcohol led to a sudden expansion of vine plantations as growing became very profitable and by 1949 wineries had no space available for receiving the grape production [71]. Vineyards on the 1969 K715 map series appear highly clustered in certain areas and not scattered all over the island. Cultivation in higher altitudes as well as in steeper slopes was abandoned in favor of altitudes in the height zone 200–600 and gentle slopes.

Although census data are not available for the northern part of the island, the distribution described in the survey of 2009 can be considered as the modern transformation of past's viticultural activity, as cultivation never exceeded 12% at the area covered by

the Central plain and the northern part. Since the 1970s, the vines have suffered a very sharp decline.

Areas under vineyards in Lemesos and Pafos regions in 1885 remained in the same regime until 1969, while expanding vineyards took up space both from the Unclassified category (could be both cultivated areas and areas under natural vegetation) in the 1885 but also with certainty from woodland after 1942 (Figure 5). The situation differs in the Troodos region that exhibits a more fluid pattern with areas shifting between viticulture and natural vegetation. In the early 20th century, the region did not follow the expansion trend between 1942 and 1969, instead significant vineyard areas were abandoned and switched to natural vegetation types (Figure 5). This trend was also observed in other Mediterranean landscapes [72].

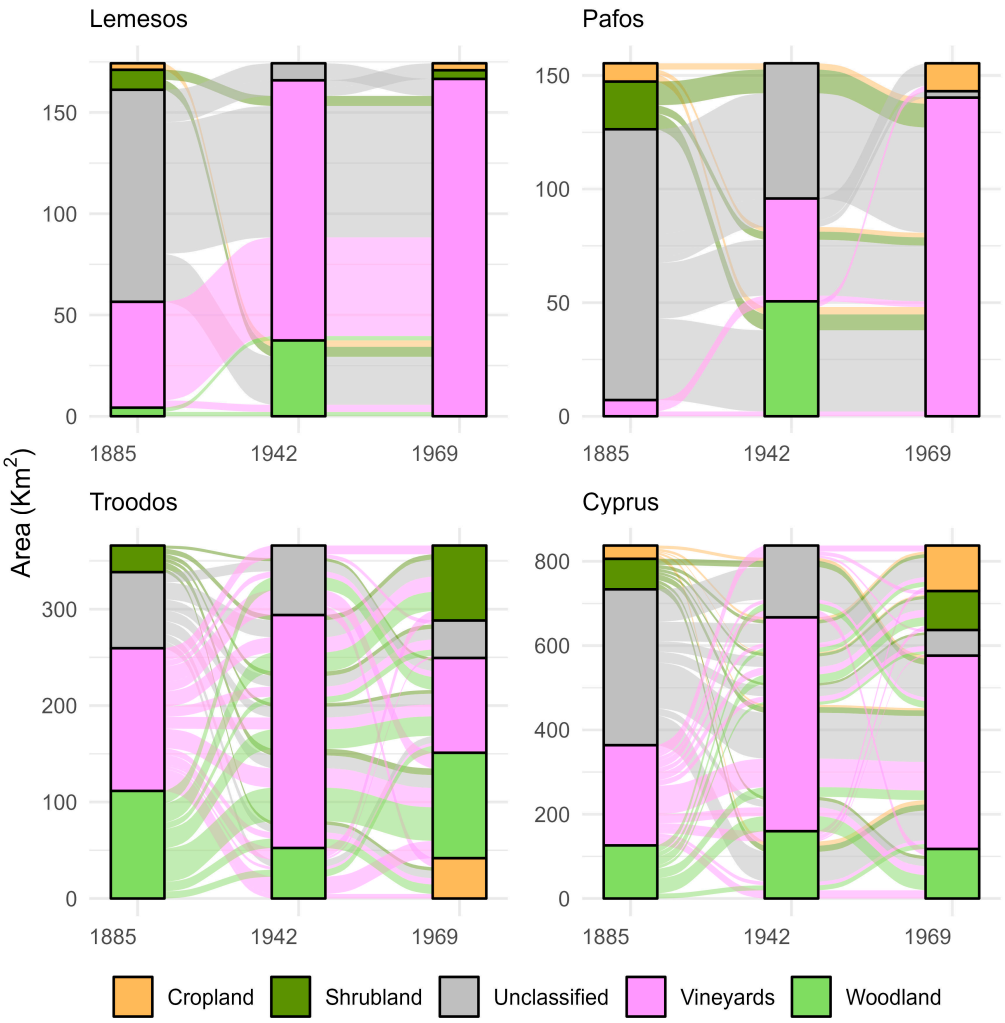

Figure 5. Transitions between land cover types for the period 1885–1969 based on historical maps, for Cyprus and the three most significant contributing physiographic regions.

Concerning the whole of Cyprus, about 27% of the vineyards from the late Ottoman period, included on K-map, were preserved until the late 1960s, as seen in K715 map. Most of these areas originated from the Lemesos physiographic region, where a stability over time was observed and from which almost all vineyards maintained their status throughout the British period.

Almost all settlements where a statistically significant high viticultural activity was observed over time, are located within the boundaries of modern era Protected Designation of Origin (PDO) areas. Only ten out of those thirty-six settlements present constantly high viticultural activity throughout the historical periods and modern era and eight of

them belong to the greater area of Krasochoria region (Figure 1). According to K-map, Krasochoria vines were established into larger contiguous areas compared to the rest of the island.

In the Lemesos, Troodos and Pafos regions, which were the hotspots of viticulture, up to the late 19th century the share of the various communities in viticulture was related to large Christian population, higher elevation and avoidance of gentle and lower slopes and valleys (Table 4). The census of 1931 seems to mark a turning point when the movement to new areas altered the environmental background of viticulture. Following that date, the avoidance of gentle and lower slopes and valleys is reduced as is the impact of population size and elevation. The same shift is observed with respect to eutric lithic LEPTOSOLS and eutric skeletic REGOSOLS, the correlation coefficient of which changes from positive prior to 1931 to negative at the end phases of the study period. Also noticeable is the loss of importance of eutric CAMBISOLS and eutric anthropic REGOSOLS and the rise in the importance of calcaric rendzic LEPTOSOLS and calcaric leptic CAMBISOLS (Table 4).

Table 4. Zero-inflated negative binomial regression model with vine area (ha) per settlement as the dependent variable except 1572 where loads were used for the calculations. Values for soil and landform categories were the area falling in each category within the limits of the respective settlement. Population was the Christian population, which equals the total population in 1572 and 2009 but not in-between (see Section 2.2.2). Elevation was the median value within the borders of each settlement. The values of explanatory variables were scaled. The "zi" part models the excess zeroes (negative signs means increased zero Y values) and the "cond" part models the quantity of the dependent variable after the effects of modeling the excess zeroes (negative signs mean decreasing value of Y). $p < 0.001$ (***); $p < 0.01$ (**); $p < 0.05$ (*); $p < 0.1$ (.); $p > 0.1$ (n.s).

	Estimators	1572	1833	1885	1931	1942	1969	2009
cond	Intercept	5.3821 (***)	1.5325 (***)	3.5712 (***)	3.4234 (***)	4.4742 (***)	4.5831 (***)	2.37 (***)
	Population	0.6138 (***)	0.9428 (***)	0.4159 (***)	0.4614 (***)	−0.1489 (n.s.)	−0.0375 (n.s.)	0.9185 (***)
	Gentle slopes	−0.856 (**)	−0.9501 (***)	−0.8394 (***)	−0.3543 (***)	−0.3707 (**)	−0.358 (**)	−0.2713 (.)
	Lower Slopes	−0.0015 (n.s.)	−0.3593 (*)	−0.5289 (***)	−0.1693 (n.s.)	−0.1612 (n.s.)	−0.3983 (**)	−0.2946 (.)
	Valleys	−0.6867 (*)	−1.2592 (***)	−1.164 (***)	−0.4317 (***)	−0.5583 (**)	−0.1693 (n.s.)	1.2242 (***)
	Elevation	0.3578 (**)	0.9143 (***)	0.6956 (***)	0.8737 (***)	0.7126 (***)	0.7769 (***)	0.4702 (***)
	calcaric rendzic LEPTOSOLS and calcaric leptic CAMBISOLS	0.0422 (n.s.)	0.3598 (***)	0.4061 (***)	0.3917 (***)	0.4099 (***)	0.5832 (***)	0.5736 (***)
	eutric CAMBISOLS and eutric anthropic REGOSOLS	0.0474 (n.s.)	0.3484 (***)	0.4738 (***)	0.1942 (**)	0.3531 (***)	0.1721 (.)	−0.0308 (n.s.)
	eutric lithic LEPTOSOLS and eutric skeletic REGOSOLS	−0.2165 (n.s.)	0.7037 (**)	0.7649 (***)	−0.219 (n.s.)	−0.0362 (n.s.)	−0.6337 (**)	−1.997 (***)
	sceletic calcaric REGOSOLS and calcaric lithic LEPTOSOLS	−0.1355 (n.s.)	0.2666 (*)	0.3513 (**)	0.1006 (n.s.)	0.1629 (n.s.)	0.2151 (*)	−0.3901 (**)
zi	Intercept	0.2174 (n.s.)	−18.988 (n.s.)	−1.1301 (***)	−4013.335 (n.s.)	−1.332 (***)	−0.5542 (***)	−274.245 (**)
	elevation	−2.4942 (***)	0.6504 (n.s.)	−2.502 (***)	1.7981 (n.s.)	−0.6737 (***)	−0.207 (.)	−2.2762 (n.s.)
	population	−0.6807 (***)	−41.952 (n.s.)	−0.389 (.)	−10,021.751 (n.s.)	−2.3966 (***)	−0.0695 (n.s.)	−1389.531 (**)

5. Discussion

Historical viticultural landscape dynamics and their major driving forces have been investigated for the island of Cyprus, using GIS-based techniques, in order to better understand the spatial dimension of viticulture's change, since the beginning of the Ottoman period in 1572. It is the first time that detailed data on viticulture from the Ottoman censuses of 1572 and 1832/33, with a degree of geolocation greater than 95%, have been compared with Kitchener's map of 1885 and analyzed to investigate spatial dispersion and

change in a land system from the Ottoman and through the British colonial period to the present state.

Since high detail data such as satellite imagery and aerial photographs are limited to a period spanning the second half of the 20th century onward, driving forces and dynamics that took place in the island's *longue durée* can only be assessed by studying historical detailed data. However, historical sources present significant challenges not only due to their limited and fragmentary availability, but also because they inherit the inaccuracies of the recorded attributes.

Historical censuses, such as maps, are abstractions of reality and they represent a selection of phenomena that under certain circumstances and methods have been organized in a form of lists by certain people. Inaccuracies occur not only due to the methods used to transfer these data into modern GIS environments, but also due to the methods, the purposes, and the reasons that they were primarily collected and therefore cannot be measured by statistical indices. For example, the first Ottoman fiscal census of 1572 was carried out after about one year of war in the central plain of Mesaoria, with an unknown impact on viticulture and agriculture of the island. Accordingly, the Ottoman property survey of 1832/33 was carried out after a both politically and socially unstable period in the early 19th century. Therefore, both these Ottoman surveys do not accurately reflect the regular state of the island's viticulture, not least because they concern extraordinary conditions (in the case of the 1572 survey, this was in the aftermath of the Ottoman–Venetian War of 1570–1571, and in 1832/33, the survey was conducted due to the decline of population on account of dire socio-economic conditions).

The biggest challenge for the Ottoman period surveys is the uncertainties over the units used. A *load*, used for liquid volume measurements in 1572, could refer to a *kuza* (8 okes), a *gomari* (16 *kuzas*) or a *pythari* (5–7 *gomaris*), which are well known units used in that period. Even if *gomari* seems the most reasonable choice, converting wine quantities into vine areas requires additionally rough estimates of yields in grapes and weight loss during the winemaking process, making any estimation highly doubtable. An Ottoman *dönüm*, used for area measurements in 1832/33, was by no means fixed and varied between 919.3–1337.8 m^2 according to the official sources [49,73,74]. However, attempts to standardize measurements and weights throughout the Ottoman empire took place in the *Tanzimat* period (1839–1876) [75], thus the variance could be higher than the official range given previously. Additionally, the *dönüm* unit was the successor of the Byzantine *stremma* or *skala* as it was called by the locals which was a variable area based on the extent of land that can be ploughed in one day [45]. It is further unclear whether the *skala* and the *dönüm* were the same. Although the translation of the Ottoman *dönüm* remains vague, quantities registered to the census of 1832/33, the estimates of Consul Fourcade [76] in 1844 of total area about 80 km^2 and the approximate calculations from Gaudry's and Damour's map and notes [77,78] of also about 80 km^2, strongly indicate that the total area under vines in Cyprus before the phylloxera outbreak in Europe, could not have been more than 100 km^2 in any case.

Uncertainties arise also in the case of the more modern British censuses and statistical records where the translation of the *dönüm* unit is clear. For example, the British Agricultural Census of 1931 lists 162.101 *dönüm* of vineyards. The Cyprus Blue Book [44] of the same year reports an area under viticulture of 117.894 acres which translates to 356,629.3 *dönüm*, making the difference confusing and highly contradicting. However, this difference is aligned with serious doubts raised by the compilers of the census that the *dönüm* land measure was computed at different sizes in different parts of the island and that taxation fear may have led growers to understate their properties. Additionally, Christodoulou [79] raises two more concerns for registered areas in censuses about semi-abandoned vineyards and sparse vineyards with gaps within them. Vineyard areas described on the GSGS 4242 map, however, are completely in line with the areas described in the last colonial statistical book published before WW2 (1938) [44] indicating that areas in the Census of 1931 are

understated. Areas on the K715 map completely correspond to the area recorded by the Food and Agriculture Organization for the same period.

Historical maps inevitably contain accumulated inaccuracies due to the method used for data collection, the cartographic projection and the degree of the cartographic generalization applied during production. Furthermore, errors are introduced during the digitization process: the boundaries between land use/cover classes are not always crisp but must be identified nonetheless. Given that a set of historical maps has been produced by different cartographic services using different technological means, it is difficult to assess their inherent inaccuracies using statistical measures of positional accuracy. However, by processing maps and cartographic datasets of the same scale using the same grid of control points in assessing the convergence between them, the likelihood that these accumulated inaccuracies follow similar patterns is greater, making RMSE useful and indicative of the comparison's accuracy.

Unfortunately, for the northern part of the island, modern data for viticultural activity have never been published in any form. Neither Corine Land Cover (CLC) layers nor Land Use/Cover Area Frame Survey (LUCAS) include vineyard classes for the northern part. Viticultural activity, however, as mentioned previously, for the area within the limits of Mesaoria, Keryneia, Ammochostos and Karpasia physiographic regions (Figure 1) has never exceeded 12% of the total throughout the Ottoman and British period.

Like elsewhere, large-scale viticulture in Cyprus was historically connected to export. Historians have in the past assumed that the Islamic prohibition for alcohol consumption, as well as the sophisticated methods wine production required, hindered viticulture [80]. More consistent research has demonstrated this to have been a misleading assumption [81], showing how viticulture had expanded in Crete following the Ottoman conquest. Our analysis confirms this for the case of Cyprus as well, although production was lower than in Crete.

Due to the reasons outlined above the total area under viticulture in 1572 cannot be estimated with any reasonable level of certainty, therefore the trends between 1572 and 1833 remain obscure. Various contemporary narratives report widely divergent estimates [82–84], that taken together suggest declining total area, a fact attributed to various factors that led to the decrease in the population between 1571 and the end of the 18th century and the negative stance of the Ottoman regime towards wine production due to its Muslim background. While this picture was widely accepted by subsequent authors [10,71,85,86], hard evidence thereof remains elusive.

During the same period, the geographical pattern exhibits an expansion taking the form of a diffusion of viticulture in the areas immediately neighboring the original centers (Figure 3). This pattern of expanding by diffusion in the surroundings persisted for the rest of the 19th century and until 1942. In this part of the study period, a clear and rapid increase in the total area under viticulture accompanies the expansion of its distribution (Table 1). Data are not globally available, but it is clear that a large part of the increase took place at the expense of natural vegetation, while rewilding of former vineyards also occurred, especially in the Troodos area (Figure 5). It seems that the practice of a decadal scale rotation consisting of abandoning old unproductive vineyards on which forest reestablishes and clearing new parcels before returning to the old ones, described as "fitful cultivation", persisted despite the efforts of the colonial forest administration to end it [87].

From 1942 onward two overall patterns are apparent: the initial stagnation of total area and subsequent decline, after 1969, of the total area and the spatial displacement of viticulture westwards. This spatial displacement resulted in contrasting geographical patterns. In the mountainous Troodos region decline occurred also before 1969 with large tracts of vineyards reverting to natural vegetation cover. On the other hand, in the Lemesos and especially in Pafos regions viticulture continued to expand at the expense of natural vegetation, among other land cover types, until 1969 (Figure 5). The shift westwards is linked to a shift in the environmental setting of viticulture; vineyards are gradually positioned at lower altitudes, gentler slopes and different soils (Tables 3 and 4). At present

and although pockets of persistence exist in the traditional viticulture areas most vineyards are located in the new areas.

A noteworthy development that requires attention is the expansion of viticulture in the mid-nineteenth century. Three developments account for this. The first one concerns the phylloxera crisis in Europe that started around 1860, spiking demand for alternative sources of wine. The second one is the introduction of industrial wine making facilities, with the establishment of ETKO as the first wine industry in 1844. The development reflects a broader trend in the Eastern Mediterranean, with the establishment of Château Ksara in Lebanon (1857) and Achaia Clauss in Greece (1861). The third factor is the overall improvement of socio-economic conditions on the island following the *Tanzimat* reforms, particularly after the 1850s [85,88], which accelerated processes of modernization that the British capitalized upon during the colonial period. This phase also coincides with a steep population growth that increased the necessary labour for this cultivation and the need for additional income generation.

Of particular interest is the fact that our analysis demonstrates that Cyprus reflected broader Mediterranean trends between the sixteenth and nineteenth centuries. The centrality of viticulture in the Mediterranean landscape has long been highlighted by Braudel [89]. Tabak, however, has argued that the picture composed by Braudel had not been a timeless feature of the Mediterranean environment, but the result of developments after the sixteenth century [90]. This is also true for Cyprus regarding the cultivation of other commodities or broader historical phenomena [40].

During the twentieth century, the two world wars negatively affected wine production in Europe and north Africa and increased the demand for ethanol and wine, providing new boost for Cypriot viticulture [71,91]. Cyprus was spared from all three crises that affected European production (phylloxera, WWI, WWII). These phases of increased demand were followed by crisis situations when they ended; however, the first two were overcome, since shortly thereafter the next crisis entered the scene. In these phases distribution change occurred as diffusion around the original center. State policies in the twentieth century significantly affected the spatial dynamics. Starting in the 1920s, and increasingly since the late 1960s, the introduction of new improved varieties encouraged the expansion to new areas where they could be more productive. At the same time, traditional vineyards were abandoned or replaced by other crops (Figure 5). It seems that the most decisive factor was the increased productivity of these varieties in the new areas (reaching three to four times the productivity in the traditional ones in the late 1970s and early 1980s) combined with the lack of capital necessary for restructuring and land suitable for intensive cultivation in the mountainous areas [91]. Considering the positioning of viticulture with respect to the quality potential evaluation of the different zones it is evident that only pockets persist in the best zones and viticulture spread in the zone with the lowest quality potential, because profitability due to increased productivity in this zone outweighed by far the potential of a quality premium in the price of grape production in the best zones [92].

Since the 1960s, a restructuring of vineyards took place, which gained momentum in the following decades and pursued different objectives: the removal of less productive vineyards from production, the replanting of those vineyards that ensured sufficient production, and the conversion to new varieties that promised higher incomes to farmers. These changes were in line with FAO guidelines and the new direction of agricultural policy since the 1980s. The policy focused on reducing vineyard acreage while encouraging conversion to new high-value grape varieties. This process continued for several decades until the mid-2000s. According to official data, the area under vines and grape production shrank drastically between 1980 and 2009 [93]; this trend continued up to 2020. Meanwhile, another fundamental trend is the ratio of tons per hectare, which has been decreasing over the decades: the average production per hectare was 6.36 tons in the 1980s, 5.52 tons in the 1990s, 5.12 tons in the 2000s and 3.36 tons in the 2010s. This downward trend illustrates the gradual evolution of viticulture on the island from productive cultivation, where the

emphasis is on increasing grape volumes, to post-productive cultivation of vines, where the emphasis is on lower production.

Another important aspect of the vineyards is the fact that the wine industry is exploiting an increasing share of the produced grapes, replacing production by the growers themselves. Between 1960 and 1980, the share of grapes in the total production of wineries increased from 42.7% to 71.5% [94], which, together with the establishment of several local wineries and the improvement of winemaking technology, led to a considerable development of the wine industry and the increased production of quality wines, especially post-1980. Winegrowers received an area subsidy from the government [95]. However, Cypriot wine companies have had major problems in promoting exports related to the type of wines produced, quality, overall cost of production, keeping in line with the ever-changing tastes and preferences of consumers that affected the structures of the markets and their segments. In the 1980s and 1990s, Cypriot wineries produced bulk wines for the Soviet Union, Germany and the United Kingdom. Nowadays, however, Cypriot wineries focus on producing quality wines to capture the mid- to high-end segment of the global wine market [96].

Overall, the trends in recent times show similarities with other Mediterranean landscapes; the shrinkage of vineyards in mountainous regions in favor of woodland throughout the 20th century, reflects the trend of agricultural abandonment and woodland recovery (among others [97–100]). The pockets that persisted through this period could be stabilizing since a shift towards investing in production of higher quality wines occurred in the last few decades [101], accompanied by EU investment and area subsidies [102].

Following the reliability, the uncertainties and the limitations of the available heterogenous historical material, this study has established through a mixed methodological approach, a long in time and rich in intermediate screenshots, reconstruction of the Cypriot viticultural landscape, contributing to the current literature of past's viticultural activity. That long and detailed time series allowed the study of the long-term drivers that shaped the spatial distribution of vineyards and governed spatial changes in relation to its social, economic, political and historical dimensions in Cyprus's *long durée*.

6. Conclusions

Viticulture dynamics in Cyprus were investigated for the period from the dawn of the Ottoman era until now. This timeline revealed the changes in spatial patterns driven by the interplay of distant and local factors. Aside from the inevitable limitations and necessary assumptions, historical maps and censuses preserve valuable information for the understanding of long-term spatial trajectories of land systems and the study of land cover change. By using environmental factors reflected in physiographic regions, topo-graphic factors, such as elevation and landforms, cultural factors, such as religion, and government policies that directly or indirectly affect viticulture, it has been possible to understand the historical evolution of this land system. This paper has demonstrated the value and the limitations of historical material for understanding the viticultural trans-formation processes in the longue durée of Cyprus, for which the contribution and evaluation of such historical sources is crucial.

After about four and a half centuries since the arrival of the Ottomans, the Venetian vines moved to the southwest and, although the vines were extended over the whole island under British rule, unequal distribution in the north–south direction over the total period is highly noticeable. The greater expansion of the vines was noticed during the outbreak of phylloxera in Europe at the beginning of the 1860. Vineyards are strongly related to the inclination of the ground: although yields are lower, the steeper they lie, the better the quality of grapes [103]. Motorization and modernization in agriculture practices as well as irrigation methods resulted in the movement of vine cultivation to more gentle slopes and lower altitudes in search for higher crop yields. The historical value of modern PDO area Krasochoria (Wine Villages) is undoubtable: viticultural activity was found to be continually significant for most of its villages throughout the investigated period,

reflecting broader Mediterranean-wide developments. The main vine-growing areas on the hills of Troodos, as all available evidence point out, have been areas of viticulture for many centuries.

Having the center of viticulture well established in the area of the southern and eastern slopes of Troodos massif, vineyards expanded mainly around the same growing area until WW2 when they gradually began to move southwest to lower altitudes from the Troodos massif to the region of Pafos as a result of state policies introducing new varieties that were more productive and hence profitable under the then prevailing conditions in areas suitable for intensive agriculture.

Since Cyprus joined the EU in 2004, viticulture has been systematically promoted by the CAP. Despite the small size of the Cypriot viticulture, important steps have been taken towards its modernization through the use of new cultivation techniques, vineyard re-structuring, introduction of new varieties, replanting, new management techniques, etc., and winemaking. In addition, new marketing techniques, technological innovations, the promotion of organic farming, phytosanitary measures, sustainability, biodiversity, etc., are part of the new strategy for viticulture and winemaking.

This study provided a comprehensive study of viticulture over the long term for an island-state of the Mediterranean and revealed the interplay of the drivers that shaped the distribution and evolution in relation with its social, economic, political, geomorphological and historical dimensions. In addition, employing a mixed methodological approach, this work provided a framework for historical reconstruction of viticulture regarding spatial distribution and change for longer time series, contributing to the current literature.

Author Contributions: Conceptualization and methodology, E.P., V.D. and C.C.; software, E.P. and V.D.; georeferencing and digitizing, E.P.; data curation, E.P.; writing—original draft preparation, E.P., V.D. and C.C.; writing—review and editing, E.P., V.D., A.H., C.V., A.G.P. and C.C.; visualization, E.P.; supervision, project administration and funding acquisition, E.P., V.D. and C.C. All authors have read and agreed to the published version of the manuscript.

Funding: This study is a part of doctoral research. The implementation of the doctoral thesis was co-financed by Greece and the European Union (European Social Fund-ESF) through the Operational Programme «Human Resources Development, Education and Lifelong Learning» in the context of the Act "Enhancing Human Resources Research Potential by undertaking a Doctoral Research" Sub-action 2: IKY Scholarship Programme for PhD candidates in the Greek Universities», granted to E.P. (Funding number: 2022-050-0502-52225).

Data Availability Statement: Not applicable.

Acknowledgments: We would like to express our special thanks to the Sylvia Ioannou Charitable Foundation for kindly providing a digital copy of Kitchener's map (M.0254) and Gaudry's and Damour's map (M0453) from its rich collection of historical maps.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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